



# CARTA 3: Cube Analysis and Rendering Tool for Astronomy

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Slides courtesy of Juergen Ott (NRAO)



# CARTA

## Cube Analysis and Rendering Tool for Astronomy

Project: ASIAA, IDIA, NRAO, U Alberta

Webpage: <https://cartavis.org>

Github: <https://github.com/CARTAVIS>

Goal: To build a high performance, versatile image for large data cubes and image in astronomy

Use cases:

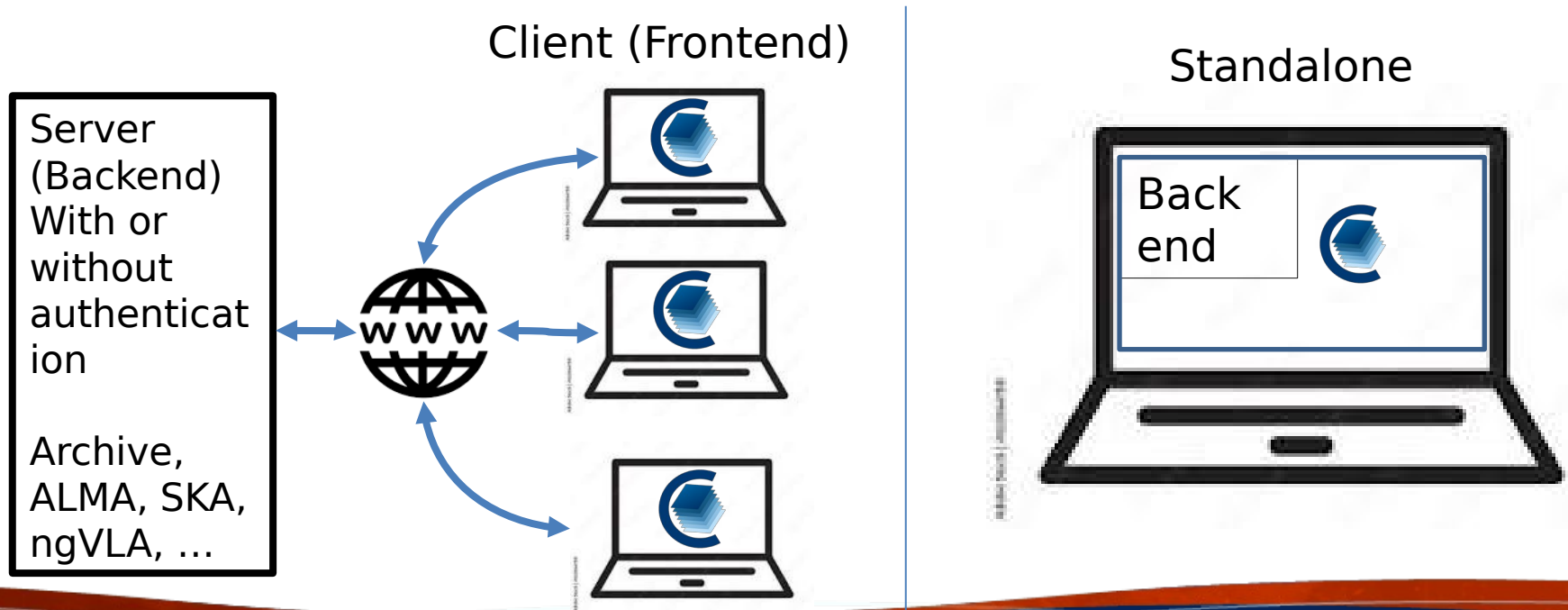
- CASA viewer replacement (excluding interactive clean and visibility display)
- Archive interface for images from SKA precursors, ALMA, NRAO SRDP
- Stand alone analysis tool
- Scriptable interface (publication ready images, interaction for analysis)
- Collaborative tool

Current release version 3.0 (release date Aug 23, 2022)



# CARTA architecture

- A focus is on the performance for large datasets (1 TB loads in seconds)
  - Memory efficient image loading
  - Parallelization and GPU-accelerated rendering
  - Progressive and responsive update of spectral profile
  - Tiled image rendering
- Image formats: CASA, fits, gzipped fits, MIRIAD, HDF5 image (cube)
- OS: MacOS, Ubuntu, RHEL
- CARTA is built as a server-client infrastructure, launched separately or in a stand-alone version in a single instance



# System Requirements to run CARTA

Two way to run CARTA, see <https://cartavis.org> “Obtaining CARTA”

- run on www server
- standalone version (restrictions)

<https://carta.readthedocs.io/en/latest/>  
“How to run CARTA?” in Browsers:

Please note that the CARTA GUI is run in the web browser environment. The supported browsers are:

- Google Chrome (tested with v91)
- Firefox (tested with v89)
- Safari (tested with v14.1)

Other browsers might be supported but they are not tested.

#### Warning

At the moment, there is a layout issue with the Safari browser, which affect usability and user experience significantly. macOS users should try to avoid using Safari to run CARTA.

#### Note

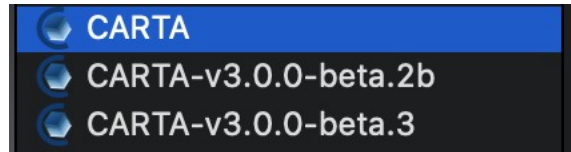
CARTA requires WebGL in order to render images properly. WebGL2 is also required to render catalog overlay properly. Please ensure WebGL and WebGL2 are enabled in your browser.

→ System/browser must be support  
webGL 2.0.  
→ If not, then CARTA widget will pop up,  
but image display will be single color  
→ Test URL:  
<https://get.webgl.org/webgl2/>  
May require upgrade or downgrade of  
video card driver

# CARTA Startup – Local

## 1. MacOX installed stand-alone:

**carta** (or click the icon in the Applications folder)



## 2. Linux at NRAO (beta version needs to be downloaded from [cartavis.org](http://cartavis.org) first):

`jott@nmpost045 ~-> carta --no_browser`

CARTA will use the default ephemerides and geodetic data.

```
[2022-10-11 17:02:20.154] [CARTA] [info] Writing to the log file: /users/jott/.carta/log/carta.log
```

```
[2022-10-11 17:02:20.154] [CARTA] [info] /tmp/.mount_cartaKMLmpa/bin/carta_backend: Version 3.0.0
```

```
[2022-10-11 17:02:20.161] [CARTA] [info] Serving CARTA frontend from /tmp/.mount_cartaKMLmpa/share/carta/frontend
```

```
[2022-10-11 17:02:20.161] [CARTA] [info] Listening on port 3002 with top level folder /, starting folder /users/jott. The number of OpenMP worker threads will be handled automatically.
```

```
[2022-10-11 17:02:20.161] [CARTA] [info] CARTA is accessible at http://10.64.10.145:3002/?token=51cb73f4-05e1-4423-92eb-9d530b8d8f69
```

```
[2022-10-11 17:02:43.453] [CARTA] [info] 0x15825b0 ::Session (1050442889:1)
```

```
[2022-10-11 17:02:43.453] [CARTA] [info] Session 1050442889 [10.64.128.247] Connected. Num sessions: 1
```

- Copy and paste this URL in your local browser and CARTA will show up

If you launch from your own Linux computer, run the app image directly:

```
> ./CARTA-v3.0.0-redhat7.ApplImage -- no_browser
```

# CARTA Startup - Remote

Most VNC session will not work! CARTA is developed for high performance and VNC disables this option through the unavailability of webgl. You will see a blank or monochrome image

Instead:

- Start a VPN session to your remote server or set up a SSH tunnel (NRAO instructions on <https://casadocs.readthedocs.io/en/latest/notebooks/carta.html> )

## On the remote Linux

```
jott@nmpost045 ~-> carta --no_browser (or ./CARTA-v3.0.0-redhat7.ApplImage -- no_browser )
```

CARTA will use the default ephemerides and geodetic data.

```
[2022-10-11 17:02:20.154] [CARTA] [info] Writing to the log file: /users/jott/.carta/log/carta.log
```

```
[2022-10-11 17:02:20.154] [CARTA] [info] /tmp/.mount_cartaKMLmpa/bin/carta_backend: Version 3.0.0
```

```
[2022-10-11 17:02:20.161] [CARTA] [info] Serving CARTA frontend from /tmp/.mount_cartaKMLmpa/share/carta/frontend
```

```
[2022-10-11 17:02:20.161] [CARTA] [info] Listening on port 3002 with top level folder /, starting folder /users/jott. The number of OpenMP worker threads will be handled automatically.
```

```
[2022-10-11 17:02:20.161] [CARTA] [info] CARTA is accessible at http://10.64.10.145:3002/?token=51cb73f4-05e1-4423-92eb-9d530b8d8f69
```

```
[2022-10-11 17:02:43.453] [CARTA] [info] 0x15825b0 ::Session (1050442889:1)
```

```
[2022-10-11 17:02:43.453] [CARTA] [info] Session 1050442889 [10.64.128.247] Connected. Num sessions: 1
```

- [Copy and paste this URL in your local browser](#)

At present only staff has access to VPN at NRAO. To remedy this, NRAO server versions for everyone are considered for the future

# CARTA Features

## Viewing:

- Image rendering with (global) min/max clipping, scaling functions and color maps
- Image panning, zooming, etc.
- Multi-panel
- Hardcopy
- Image/region saving
- Image blinking
- Image WCS matching spatially and spectrally
- Contours with different generators, colors, color maps
- Catalog overlays
- Setting of rest frequency
- Vector overlays
- Complex image display
- LEL image arithmetic before display
- Generating computed polarization quantities (eg. linear polarization intensity) of a Stokes cube on the fly
- Setting a new rest frequency when saving a subimage

# CARTA Features

## Tools/Analysis:

- Regions: rotating box, ellipses, polygons, line, point, polyline
- Spatial (X, Y) and spectral (Z) profiles
- Spectral profiles can convert spectral axis labels (velocity, frequency, wavelength)
- Histogram
- Image/Region Statistics
- Stokes analysis widget
- Moment generator
- pV diagram
- Spectral line labelling
- Spectral smoothing
- Distance measuring tool
- Intensity conversion
- 2D Gaussian fitting of sources in image
- Line and polyline region spectral profiler



# CARTA Features

## Other:

- Server-client infrastructure for remote image access
- Server authentication
- Tiled rendering for performance
- Docking and Preferred layouts and layout saving
- Scripting is under active development

# File loading

**Append vs load image difference!**

**File Browser**

Users > jott > Documents > CARTA > demo

Filename	Type	Size	Date
fft-cube.im	CASA	251.0 MB	26 May 2021
fft.test	CASA	4.4 MB	26 May 2021
IRC10216.36GHzcont.image.fits	FITS	368.6 kB	29 Sep 2020
IRC10216_HC3N.cube_r0.5.image	CASA	19.4 MB	5 Jan 2020
IRC10216_HC3N.cube_r0.5.image-copy	CASA	19.4 MB	18 Mar 2020
IRC10216_HC3N.cube_r0.5.image.fits	FITS	18.7 MB	18 Mar 2020
IRC10216_HC3N.cube_r0.5.image.mir	Miriad	19.3 MB	18 Mar 2020
m82-car-2000.fits	FITS	4.0 MB	18 Mar 2020
m82-tan-2000.fits	FITS	4.0 MB	18 Mar 2020
NGC628_dss.fits	FITS	371.5 kB	9 Nov 2020
NGC628_galex.fits	FITS	371.5 kB	9 Nov 2020
NGC_628_CUBE-bin3.image	CASA	79.8 MB	9 Nov 2020
NGC_628_CUBE.image	CASA	251.0 MB	9 Nov 2020
NGC_628_NA_CUBE_THINGS.copy.fits	FITS	247.7 MB	26 May 2021
NGC_628_NA_CUBE_THINGS.copy.mir	Miriad	243.3 MB	26 May 2021
NGC_628_NA_CUBE_THINGS.copy.mir-manipulated	Miriad	243.3 MB	26 May 2021

Filter by filename with fuzzy search

**File Information**

Name = IRC10216.36GHzcont.image.fits  
HDU = 0  
Shape = [300, 300, 1, 1]  
Number of channels = 1  
Number of polarizations = 1  
Coordinate type = Right Ascension, Declination  
Projection = SIN  
Image reference pixels = [151, 151]  
Image reference coords = [09:47:57.3820, +013.16.40.6600]  
Image ref coords (deg) = [146.989 deg, 13.278 deg]  
Pixel increment = [-0.4", 0.4"]  
Pixel unit = Jy/beam  
Celestial frame = FK5, J2000  
Spectral frame = LSRK  
Velocity definition = RADIO  
Restoring beam = 2.81862" X 1.53258", -19.1115 deg

Close Load

**No file loaded**  
Load a file using the menu

**No file loaded**  
Load a file using the menu

# Help

? = help menu

NGC\_628\_NA\_MOM0\_THINGS.fits

WCS: (1:36:42.3, 15:47:11); Image: (512, 512); NaN\*; Polarization: Stokes I

Image Active Region Active

55.00  
50.00  
45.00  
15:40.00  
35.00  
Decination

30 1:37:00 30  
Right ascension

Render Configuration X

90% 95% 99% 99.5% 99.9% 99.95% 99.99%

0 50 100 150 200  
Value (JY/B\*M/S)

1) Navigation

- Pan image click
- Pan image (inside region) middle-click
- Pan image (inside region) cmd click
- Zoom image mouse-wheel

2) Regions

- Toggle region creation mode C
- Toggle current region lock L
- Unlock all regions shift L
- Delete selected region del
- Delete selected region backspace
- Deselect region/Cancel region creation esc
- Switch region creation mode cmd
- Symmetric region creation shift
- Region properties double-click

3) Frame controls

- Next image alt ]
- Previous image alt [
- Next channel alt up
- Previous channel alt down
- Next Stokes cube alt shift up

Invert color map

Bias / Contrast

Cursor X

Region Active

0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1  
X coordinate

Cursor X

Region Active

0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1  
Y coordinate

Animator X Region List X

Layers	Matching	Channel	Polarization
628_NA_MOM	R	XY R	0 Stokes I

# Help

NGC\_628\_NA\_MOM0\_THINGS.fits

WCS: (1:36:42.3, 15:47:11); Image: (512, 512); NaN\*; Polarization: Stokes I

Declination

Right ascension

Value (JY/B\*M/S)

Render Configuration X

90% 95% 99% 99.5% 99.9% 99.95% 99.99% 100% Custom

Clip Min: -0.527750086472

Clip Max: 156.3205420161e

Scaling: Linear

Color map

Invert color map

Bias / Contrast

X Profile: Cursor

Image Active

Y Profile: Cursor

Image Active

Image List X

Image NGC\_628\_N

**Image View**

The image viewer widget serves as the core component of CARTA. It allows you to visualize images in rasters and in contours. Region of interests can be defined interactively with the image viewer and subsequent image analysis can be performed with other widgets. Catalogue files can be loaded and visualized in the image viewer with the Catalogue widget.

Images can be loaded via **File -> Open image** (will close all loaded image first). You may load multiple images via **File -> Append image**. All images are loaded in the same widget. Contour layers can be further generated via the contour widget.

World coordinates and image coordinates at the cursor position are displayed in the top of the image viewer. To freeze/unfreeze the cursor position, press **F** key.

**Image tool buttons**

A set of tool buttons is provided at the bottom-right corner when hovering over the image viewer. You may use these buttons to

- Select a source from catalog overlay
- Create regions
- Change image zoom scale
- Trigger WCS matching
- Change grid overlay reference frame
- Enable/disable grid lines and coordinate labels
- Export image

**Catalog selection**

- Create region
- Pan and select mode
- Zoom in
- Zoom out
- Zoom to fit screen resolution

**Image tool buttons**

- Export image
- Toggle labels
- Toggle grid
- Overlay coordinate
- WCS matching
- Zoom to fit image view

**Zoom and pan**

Zoom actions can be triggered in different ways. The most common one is to use mouse and scroll wheel. By scrolling up, image is zoomed in, while by scrolling down, image is zoomed out. Alternatively, you may use the tool buttons at the bottom-right corner of the image viewer to zoom in, zoom out.

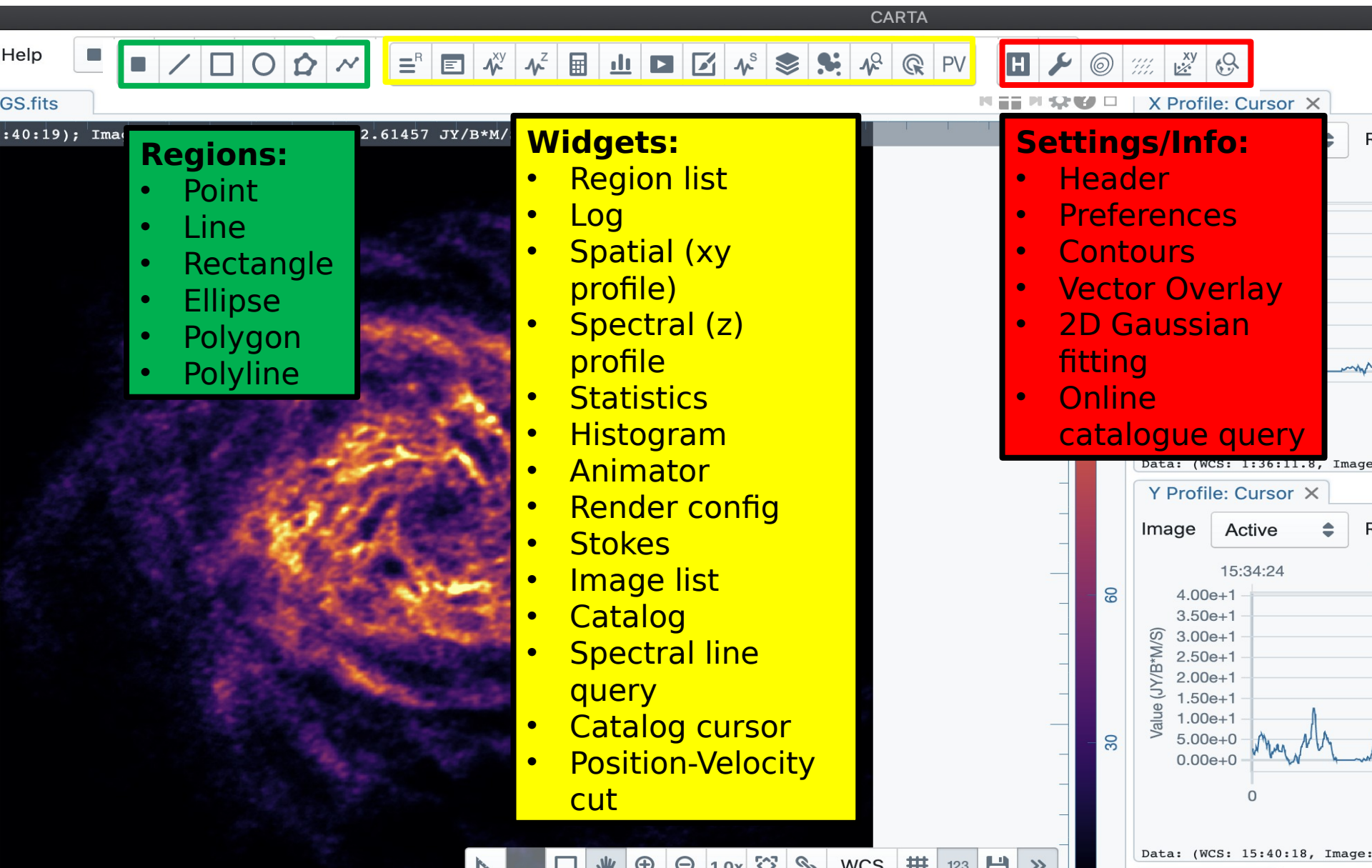
# Widgets

The screenshot displays the CARTA v3 software interface. The main window shows a radio telescope image of NGC 628 with a color scale on the right ranging from 0 to 150 Jy/B/M/Hz. A menu is open, showing options like 'Theme', 'Layouts', 'Images', 'File header', 'Contours', 'Code snippets', and 'Online Catalog Query'. The 'Layouts' menu is expanded, showing 'Existing Layouts' with sub-options: 'Default', 'Cube View', 'Cube Analysis', 'Continuum Analysis', and 'test'. A red arrow points to the 'test' option. On the right, there are two profile plots: 'X Profile: Cursor' and 'Y Profile: Cursor', both showing Value (Jy/B/M/Hz) vs. coordinate. Below these are tabs for 'Image List', 'Animator', and 'Region List'. The 'Image List' tab is active, showing a table with columns: Image, Layers, Matching, Channel, and Polarization. The table contains one row: Image: NGC\_628\_NA\_MON, Layers: R, Matching: XY R, Channel: 0, Polarization: Stokes I. At the bottom, there are controls for 'Clip Min', 'Clip Max', 'Scaling' (set to Linear), 'Color map', 'Invert color map', and 'Bias / Contrast'.

**Widgets:**

- Pre-defined layouts
- Layouts can be saved and restored
- Or defined for startup

# Widgets



## Regions:

- Point
- Line
- Rectangle
- Ellipse
- Polygon
- Polyline

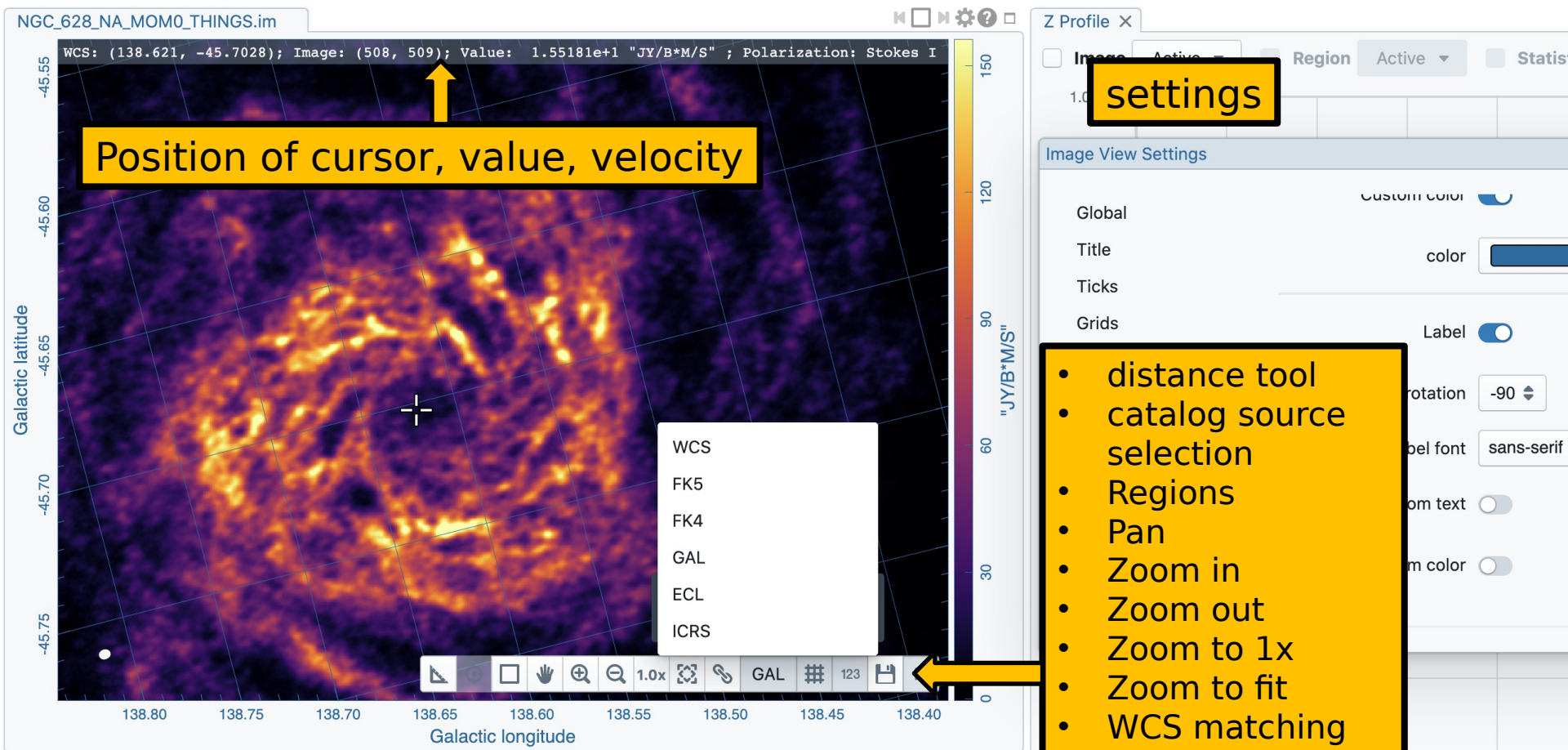
## Widgets:

- Region list
- Log
- Spatial (xy profile)
- Spectral (z) profile
- Statistics
- Histogram
- Animator
- Render config
- Stokes
- Image list
- Catalog
- Spectral line query
- Catalog cursor
- Position-Velocity cut

## Settings/Info:

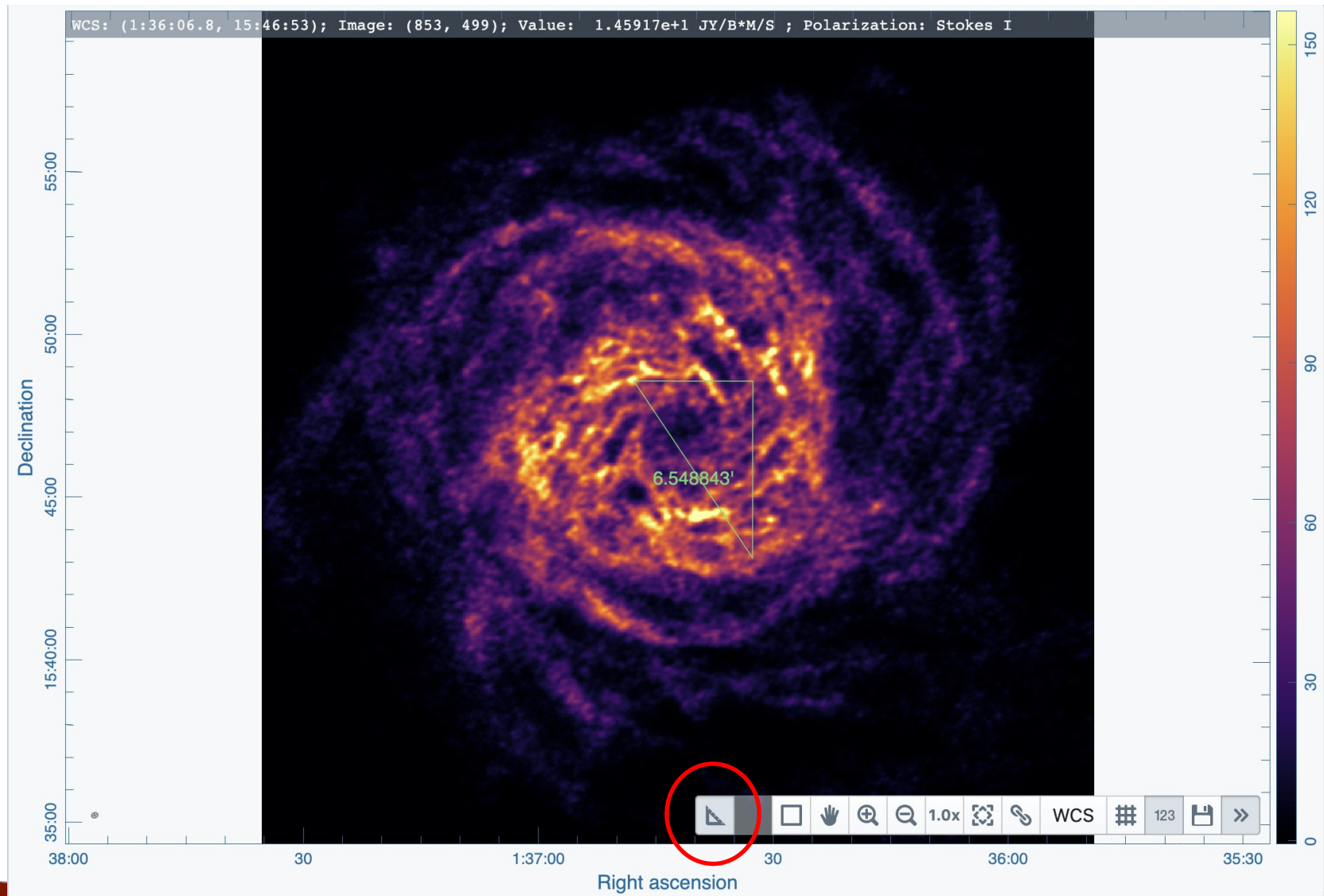
- Header
- Preferences
- Contours
- Vector Overlay
- 2D Gaussian fitting
- Online catalogue query

# Image display widget



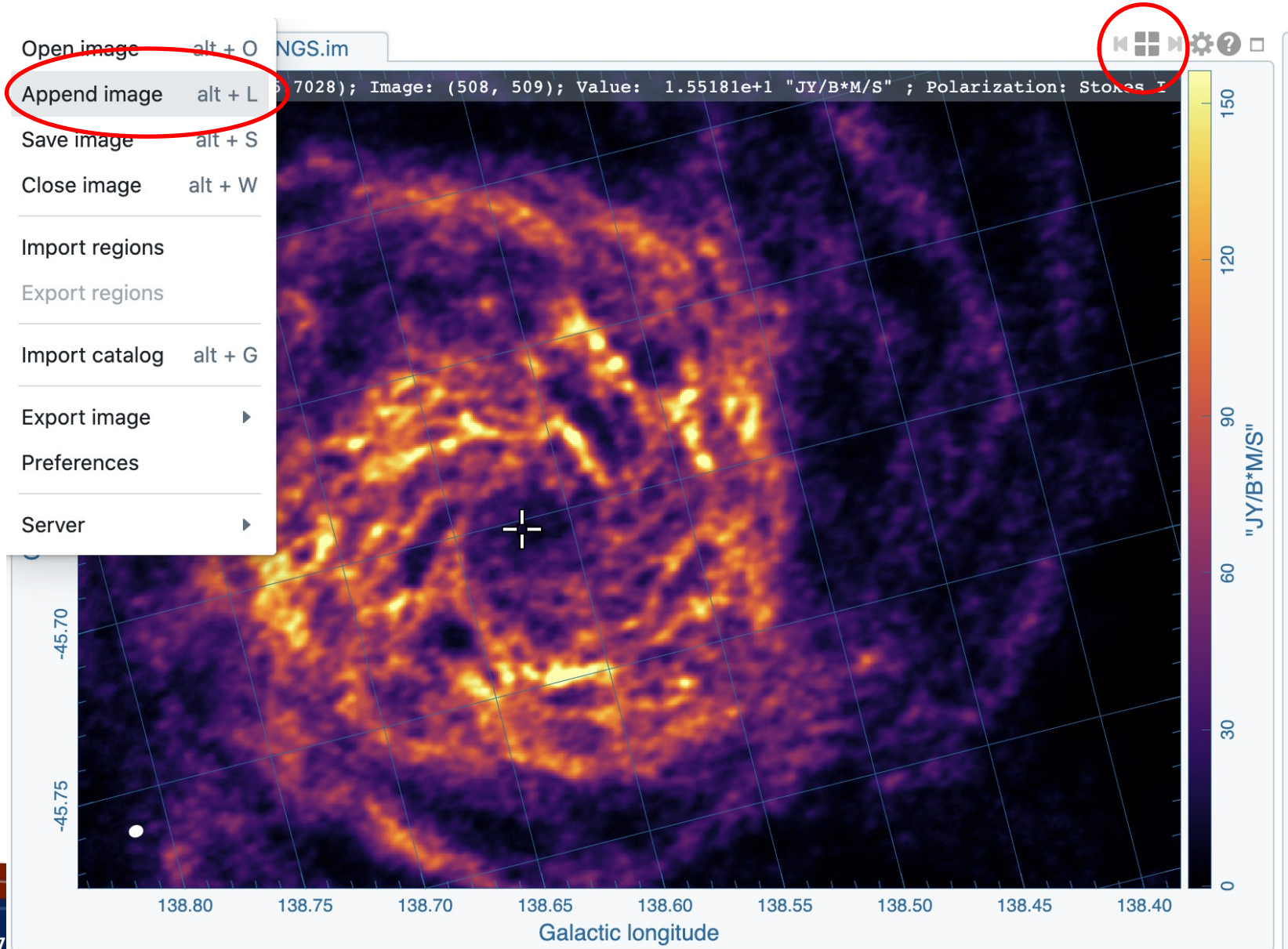
- distance tool
- catalog source selection
- Regions
- Pan
- Zoom in
- Zoom out
- Zoom to 1x
- Zoom to fit
- WCS matching
- Overlay coordinate
- Grid
- Labels
- Export

# Distance Measurement



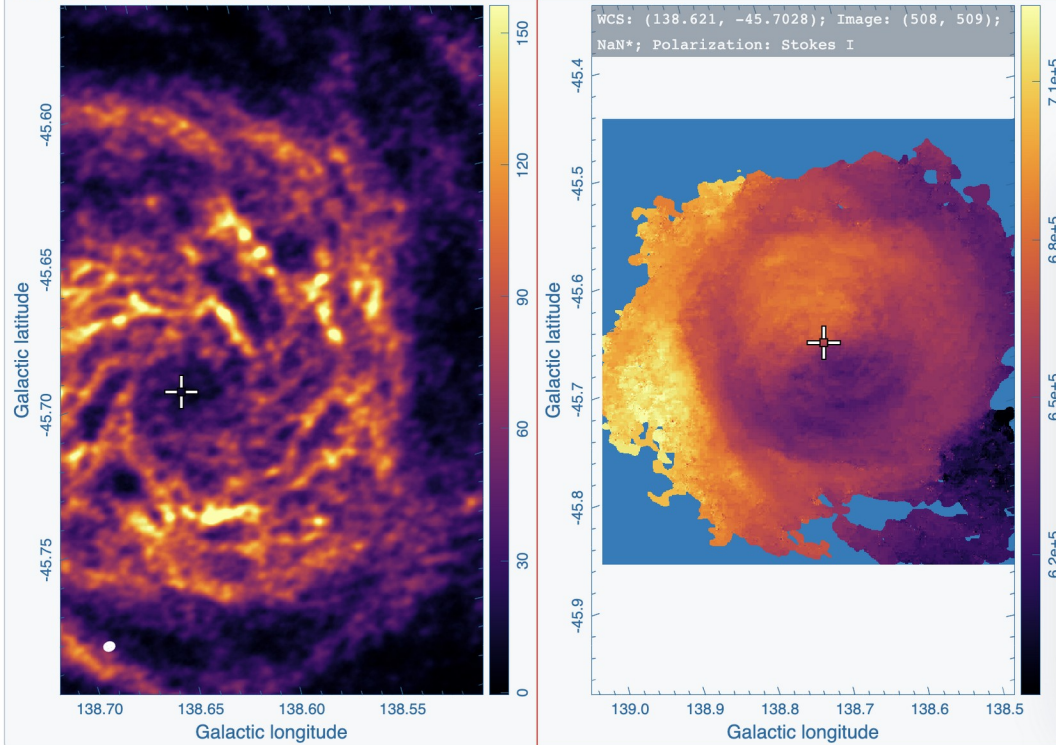


# Image display widget - multipanel



# Image display widget - multipanel

NGC\_628\_NA\_MOM1\_THINGS.fits



Z Profile X Image List X

Image	Layers	Matching	Channel	Polarization
0 NGC_628_NA_MOM	R	XY R	0	Stokes I
1 NGC_628_NA_MOM	R	XY R	0	Stokes I

Image View Settings

Global

Enable multi-panel

Title

Ticks

Grids

Border

Axes

Numbers

Labels

Colorbar

Beam

Conversion

Multi-panel mode: Dynamic grid size

Columns (Maximum): 2

Rows (Maximum): 2

Overlay color: [Blue]

Tolerance (%): 2

Labelling: Exterior

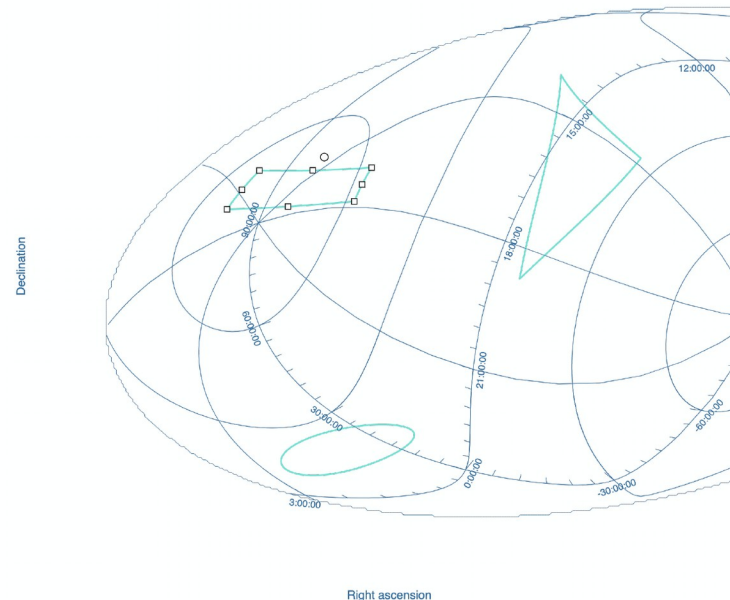
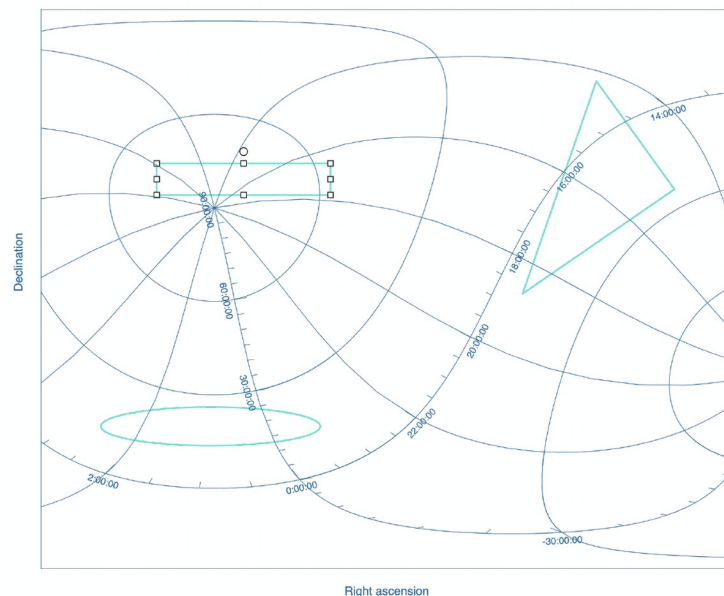
Coordinate system: Galactic

# CARTA – Projection handling

To avoid regridding, WCS matching shifts and rotates the image to the master image. This produces a small error for large fields, only visible in Blinking. But images are projected correctly when overlaid as contours.

Spectral matching: Nearest interpolation

Regions: They project correctly when moving across the sky in different coordinate systems



# Regions

Regions can be created (point, line, rectangle, ellipse, polygon, polyline), deleted, rotated, moved, resized. They are properly projected when moved

Save/load in CASA CRTF or DS9 format

Analysis can be done on selected regions (line and polyline for profiles, pV)

Image/region statistics

Statistic	Value
NumPixels	1.004400000000e+4 pixel(s)
Sum	5.981929250343e+0 Jy/beam
FluxDensity	1.075293468074e-1 Jy
Mean	5.955724064459e-4 Jy/beam
StdDev	6.466255422501e-4 Jy/beam
Min	-1.376286731102e-3 Jy/beam
Max	2.989372937009e-3 Jy/beam
Extrema	2.989372937009e-3 Jy/beam
RMS	8.790844407221e-4 Jy/beam
SumSq	7.761897275170e-3 (Jy/beam) <sup>2</sup>

Image/region histogram

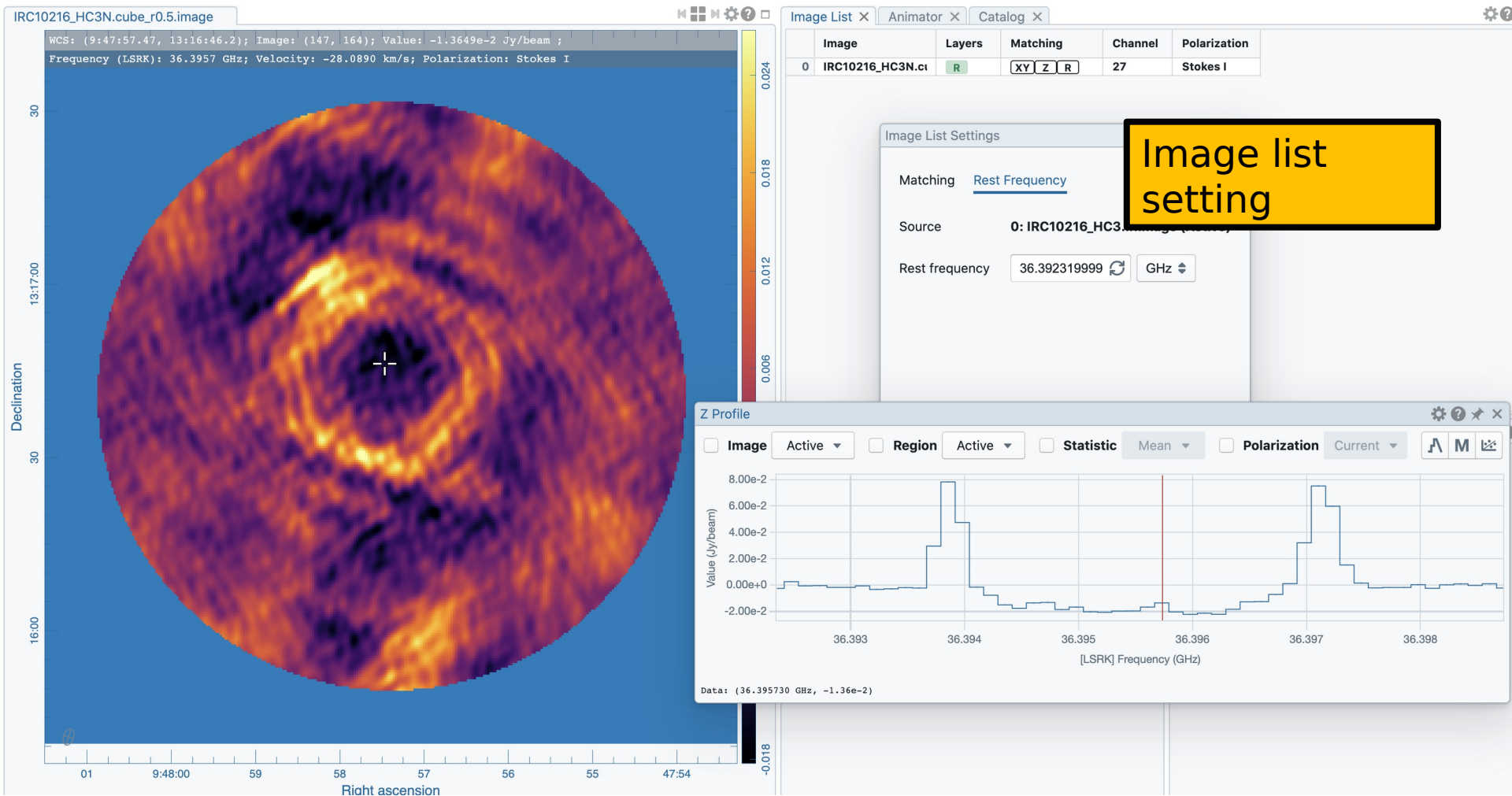
Count

Value

Y coordinate

Data: (WCS: -45.6682, Image: 630 px, 4.87879e-3)

# Set new rest frequency



# Saving subimages

Select portion of image  
(assign new rest frequency if desired)

The screenshot shows the CARTA v3 interface. On the left, a radio image of IRC10216\_HC3N.cube\_r0.5.image is displayed with a rectangular selection box. The axes are labeled 'Right ascension' (ranging from 01 to 56) and 'Declination' (ranging from 16:00 to 13:17:00). A 'File Browser' window is open, showing a list of files with columns for 'Filename', 'Type', and 'Size'. The 'Save Image' panel is also visible, showing the source as 'IRC10216\_HC3N.cube\_r0.5.image', the region as '1 (RECTANGLE)', and the range unit as 'Frequency (GHz)'. The range from and to values are 36.39235438064446 GHz and 36.39873012520509 GHz, respectively. The 'Drop degenerate axes' option is checked.

Filename	Type	Size
fft-cube.im	CASA	251.0 MB
fft.test	CASA	4.4 MB
IRC10216.36GHzcont.image.fits	FITS	368.6 kB
IRC10216_HC3N.cube_r0.5.image	CASA	19.4 MB
IRC10216_HC3N.cube_r0.5.image-copy	CASA	19.4 MB
IRC10216_HC3N.cube_r0.5.image.fits	FITS	18.7 MB
IRC10216_HC3N.cube_r0.5.image.mir	Miriad	19.3 MB
m82-car-2000.fits	FITS	4.0 MB
m82-tan-2000.fits	FITS	4.0 MB
NGC628_dss.fits	FITS	371.5 kB
NGC628_galex.fits	FITS	371.5 kB
NGC_628_CUBE-bin3.image	CASA	79.8 MB
NGC_628_CUBE.image	CASA	251.0 MB
NGC_628_NA_CUBE_THINGS.copy.fits	FITS	247.7 MB
NGC_628_NA_CUBE_THINGS.copy.mir	Miriad	243.3 MB
NGC_628_NA_CUBE_THINGS.copy.mir-manipulated	Miriad	243.3 MB

Save Image File Information Header

Source IRC10216\_HC3N.cube\_r0.5.image

Region 1 (RECTANGLE)

Range unit Frequency (GHz)

LSRK

Range from 36.39235438064446 (GHz)

Range to 36.39873012520509 (GHz)

Drop degenerate axes

IRC10216\_HC3N.cube\_r0.5.image CASA

No catalog file loaded  
Load a catalog file using the menu

No catalog file loaded  
Load a catalog file using the menu

# Contours

• Match the coordinates for multiple images

The screenshot shows the CARMA software interface. At the top, there's a menu bar (File, View, Widgets, Help) and a toolbar. Below the toolbar, there are three main panels:

- Left Panel:** Displays two astronomical images of NGC 628. The top image is a grayscale image with a crosshair at the center. The bottom image is a color image of the same field, also with a crosshair.
- Middle Panel:** Shows a contour overlay on the color image. It includes WCS coordinates: (138.613, -45.7517) and Image: (551, 399). The value is 6.31224e+5 METR/SEC, and the polarization is Stokes I.
- Right Panel:** Contains an 'Image List' table and a 'Contour Configuration' dialog box.

Image	Layers	Matching	Channel	Polarization
0 NGC_628_NA_MOM	R	XY R	0	Stokes I
1 NGC_628_NA_MOM	R	XY R	0	Stokes I
2 NGC_628_NA_CUBE	R	XY Z R	29	Stokes I

The 'Contour Configuration' dialog box shows the following settings:

- Data: NGC\_628\_NA\_MOM1\_THINGS.fits
- Source: [locked]
- Levels: Configuration Styling
- Generator: min-max-scaling [Generate]
- Parameters: Min 5.933e+5, Max 7.246e+5, N 9, Scaling Linear
- Buttons: Clear, Apply, Close

Below the dialog box, there is an 'X Profile: Cursor' plot showing 'Value (METR/SEC)' vs 'Value (METR/SEC)' with a blue line graph and vertical red lines indicating contour levels.

Append multiple images

Contour overlay:  
Create contours in various ways: percentage, min max, scaling, direct input, etc. The contour levels are shown on an image histogram and can be edited  
Styling allow color map as well as constant color

# Contours

CARTA

File View Widgets Help

NGC\_628\_NA\_MOM1\_THINGS.fits

Galactic latitude

Galactic longitude

WCS: (138.613, -45.7517); Image: (551, 399);  
Value: 6.31224e+5 METR/SEC ;  
Polarization: Stokes I

Image	Layers	Matching	Channel	Polarization
0	NGC_628_NA_MOM1_THINGS.fits	XY R	0	Stokes I
1	NGC_628_NA_MOM1_THINGS.fits	R C	0	Stokes I
2	NGC_628_NA_CUBE	XY Z R	29	Stokes I

Image List X Animator X

X Profile: Cursor X

Image Active

Value (METR/SEC)

Y Profile: Cursor X

Image Active

Value (METR/SEC)

Contour Configuration

Data: NGC\_628\_NA\_MOM1\_THINGS.fits

Source

Levels Configuration Styling

Thickness: 3

Dashes: NegativeOnly

Color Mode: Color-mapped

Color Map

Bias: 0

Contrast: 1

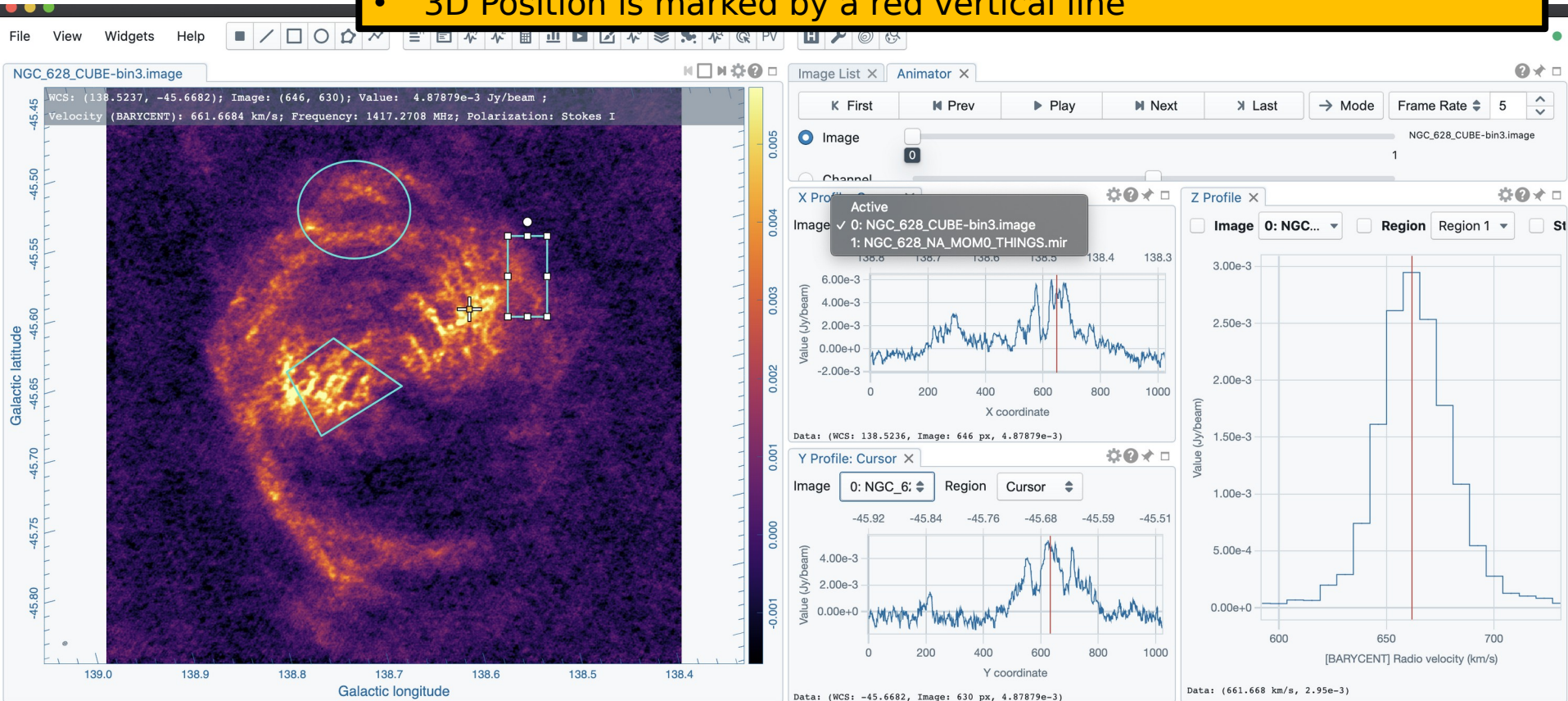
Color

Clear Apply Close

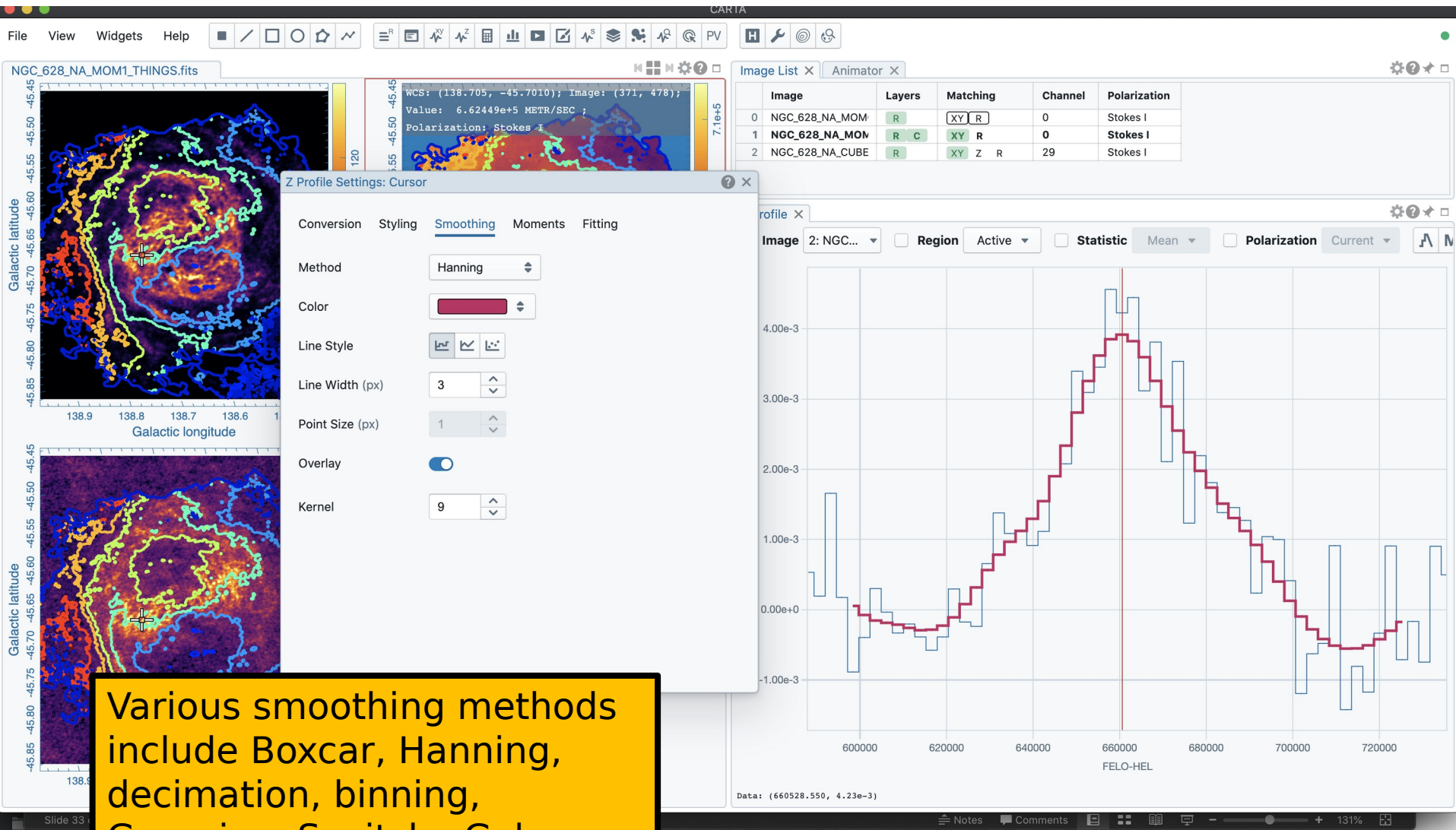


# Profiles

- Spatial/Spectral profile: Line shape can be changed (color, steps/connect/points), spectral smoothing; data can be saved as ascii
- Marker is the position of the cursor/animater (freeze with 'f')
- Selection of region and image in each widget
- For spectral profile, regions can be selected, as well as statistics, axis labels (velocity, frequency, channel, wavelength, ..)
- 3D Position is marked by a red vertical line



# Spectral smoothing



Various smoothing methods include Boxcar, Hanning, decimation, binning, Gaussian, Savitzky-Golay

# Moment maps

Spectral selection can be done interactively, including clip. Images can be saved

The screenshot displays the CARTA v3 interface with several key components:

- Image List:** A table listing loaded images:
 

Image	Layers	Matching	Channel	Polarization
0 NGC_628_NA_CUBE	R	XY Z R	29	Stokes I
1 NGC_628_NA_CUBE	R	XY R	0	Stokes I
2 NGC_628_NA_CUBE	R	XY R	0	Stokes I
- Z Profile:** A plot showing intensity versus FELO-HEL frequency. The x-axis ranges from approximately 600,000 to 740,000. A red histogram shows the profile, with a vertical red line at approximately 660,000. A shaded region highlights the area around the peak.
- Z Profile Settings: Cursor:** A dialog box for configuring the Z profile.
  - Image: 0: NGC\_628\_
  - Region: Active
  - Coordinate: FELO-HEL (Native WCS)
  - System: (dropdown)
  - Range: From 638082.3 To 687531.7
  - Mask: None
  - Range (JY/BEAM): From 0 To 1
  - Moments: 0 x 1 x
  - Buttons: Conversion, Styling, Smoothing, Moments, Fitting, Generate
- Moment Maps:** Three maps are shown:
  - Top-left: Weighted coordinate moment map.
  - Top-right: Another moment map with a different color scale.
  - Bottom-left: A zoomed-in moment map with WCS information:
 

WCS: (138.4836, -45.6577); Image: (705, 671);  
 Value: 6.65597e+2 km/s;  
 Polarization: Stokes I

# Spectral line labeling

Based on splatalogue, select line strength, frequency range and redshift

**Image List**

Image	Layers	Matching	Channel	Polarization
0 NGC_628_NA_CUBE	R	XY Z R	29	Stokes I
1 NGC_628_NA_CUBE	R	XY R	0	Stokes I
2 NGC_628_NA_CUBE	R	XY R	0	Stokes I

**Spectral Line Query**

Range: From 1400 To 1450 MHz Intensity Limit:

Name	Display	Description
1 Line selection	<input checked="" type="checkbox"/>	Column for line selection
2 Species	<input checked="" type="checkbox"/>	Descriptive formula of molecular species
3 Chemical Name	<input checked="" type="checkbox"/>	Common chemical name for species
4 Shifted Frequency	<input checked="" type="checkbox"/>	Shifted frequency according to the input velocit...
5 Rest Frequency	<input checked="" type="checkbox"/>	Frequency at the rest frame

Velocity (km/s): 660

Click to	Species	Chemical Name	Shifted Frequency	Rest Frequency	Rest Fre
<input type="checkbox"/>	c-C6H5OH	Phenol	1416.7870696951716	1419.90960	0.0015
<input type="checkbox"/>	c-C6H5OH	Phenol	1416.9656760553762	1420.08860	0.0015
<input type="checkbox"/>	17OD	Hydroxyl radical	1416.9710641802092	1420.09400	0.0152
<input type="checkbox"/>	H&beta;	Hydrogen Recombin...	1417.1117541064036	1420.23500	0
<input checked="" type="checkbox"/>	H-atom	Atomic Hydrogen	1417.2821784992693		
<input type="checkbox"/>	bc-C4H4C2...	Bicyclo[2.2.0]hexadi...	1417.3723797001771	1420.49620	0.0123
<input type="checkbox"/>	g-CH3CH2...	gauche-Ethanol	1417.6347015554718	1420.75910	0.0042
<input type="checkbox"/>	He&beta;	Helium Recombinatio...	1417.6894808246072	1420.81400	0
<input type="checkbox"/>	C&beta;	Carbon Recombinati...	1417.8191949409568	1420.94400	0

Showing 455 line(s). Selected 2 line(s).

**Spectral Profiler** | spectral-profiler-0 | Filter | Reset | Plot | Clear

**Spectral Profiler Plot**

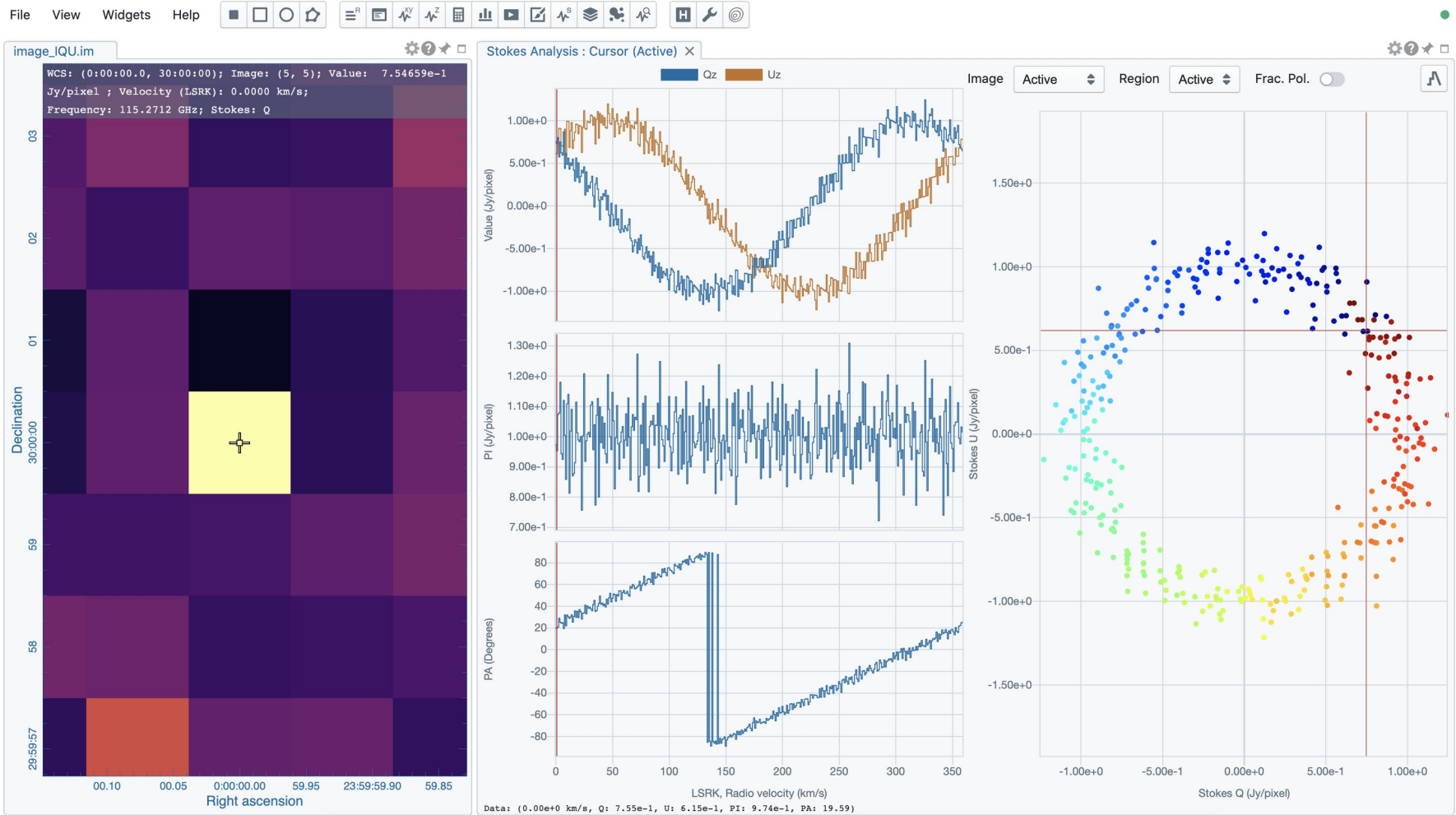
Intensity vs. Frequency (MHz)

Labels: H-atom 2S1/2, F=1-0; H&beta;: H(209) beta;

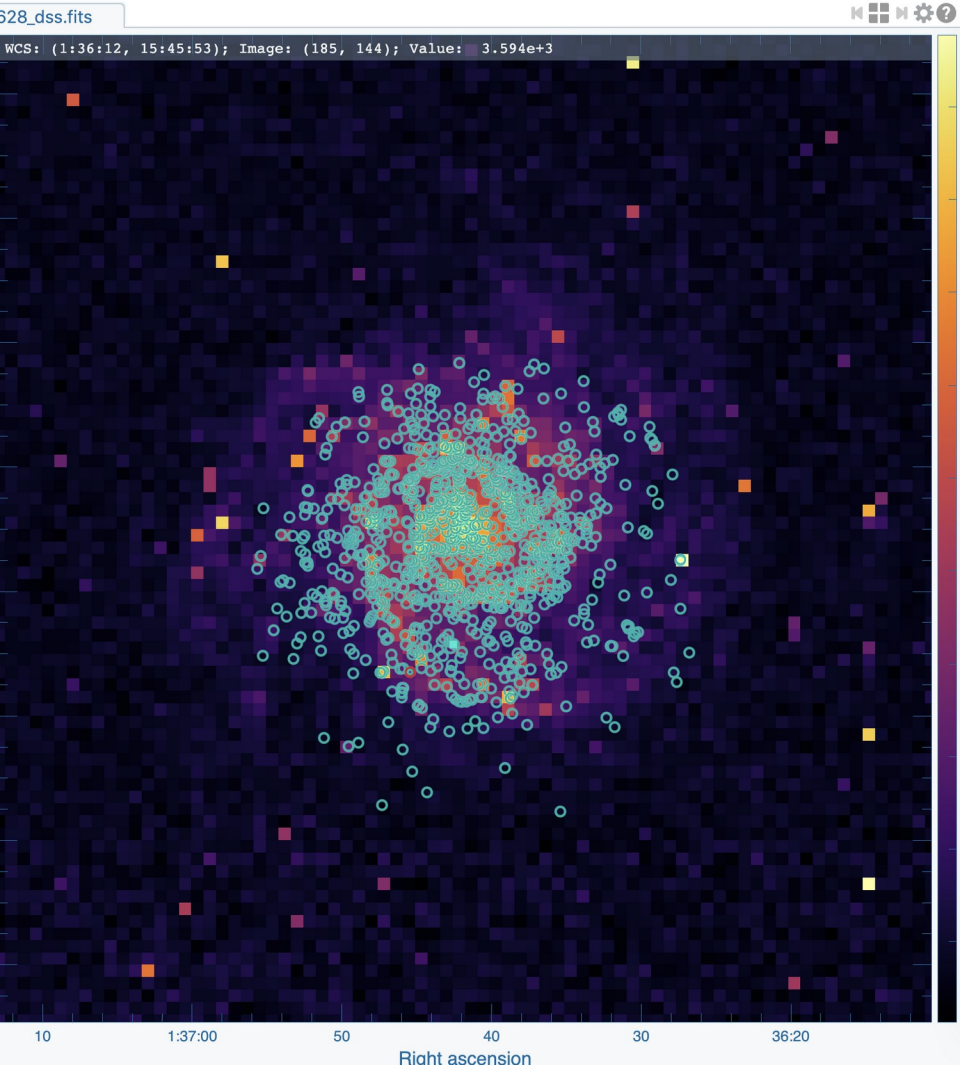
Data: (660528.550, 5.12e-3)



# CARTA – Stokes Analysis Widget



# CARTA - Catalog tool



Catalog : SIMBAD\_ICRS\_24.1698\_15.7629\_0.39603062065956496deg

File 1 System FK5

Name	Unit	Type	Display	Description
56	vlsr	double	<input type="checkbox"/>	velocity in Local Standard of Rest r...
57	main_id	string	<input checked="" type="checkbox"/>	Main identifier for an object
58	otype_txt	string	<input type="checkbox"/>	Object type
59	ra	deg	<input checked="" type="checkbox"/>	Right ascension
60	dec	deg	<input checked="" type="checkbox"/>	Declination
61	dist	arcsec	<input type="checkbox"/>	Distance to the center coordiante (...)
62	RA_HMS	H:M:S	<input type="checkbox"/>	RA in sexagesimal format (H:M:S, c...

main_id	ra	dec
Click to filter	Click to filter	Click to filter
[SRM2012] NGC628...	24.17787	15.74521
[HC2009b] M74-4	24.115916666666667	15.745027777777778
[SRM2012] NGC628...	24.18936	15.74515
[SRM2012] NGC628...	24.17787	15.74521
[VSH98] NGC 628 + ...	24.196710416666667	15.745277777777776
[RGS2017] NGC 628 ...	24.15819	15.74533
[SRM2012] NGC628...	24.1836	15.74547
[KGB2017] SNR 12	24.178083333333337	15.745472222222222
[RGS2017] NGC 628 ...	24.1558	15.74589
[SRM2012] NGC628...	24.1615	15.746
[SRM2012] NGC628...	24.19208	15.74602
[SRM2012] NGC628...	24.16446	15.74603
[SAB2010] SNR7	24.191250000000004	15.746138888888888
[SRM2012] NGC628...	24.18619	15.74618
[HC2009b] M74-148	24.147166666666667	15.746527777777777
[SRM2012] NGC628...	24.18172	15.74668
[KGR2017] PN 60	24.177708333333335	15.746999999999998

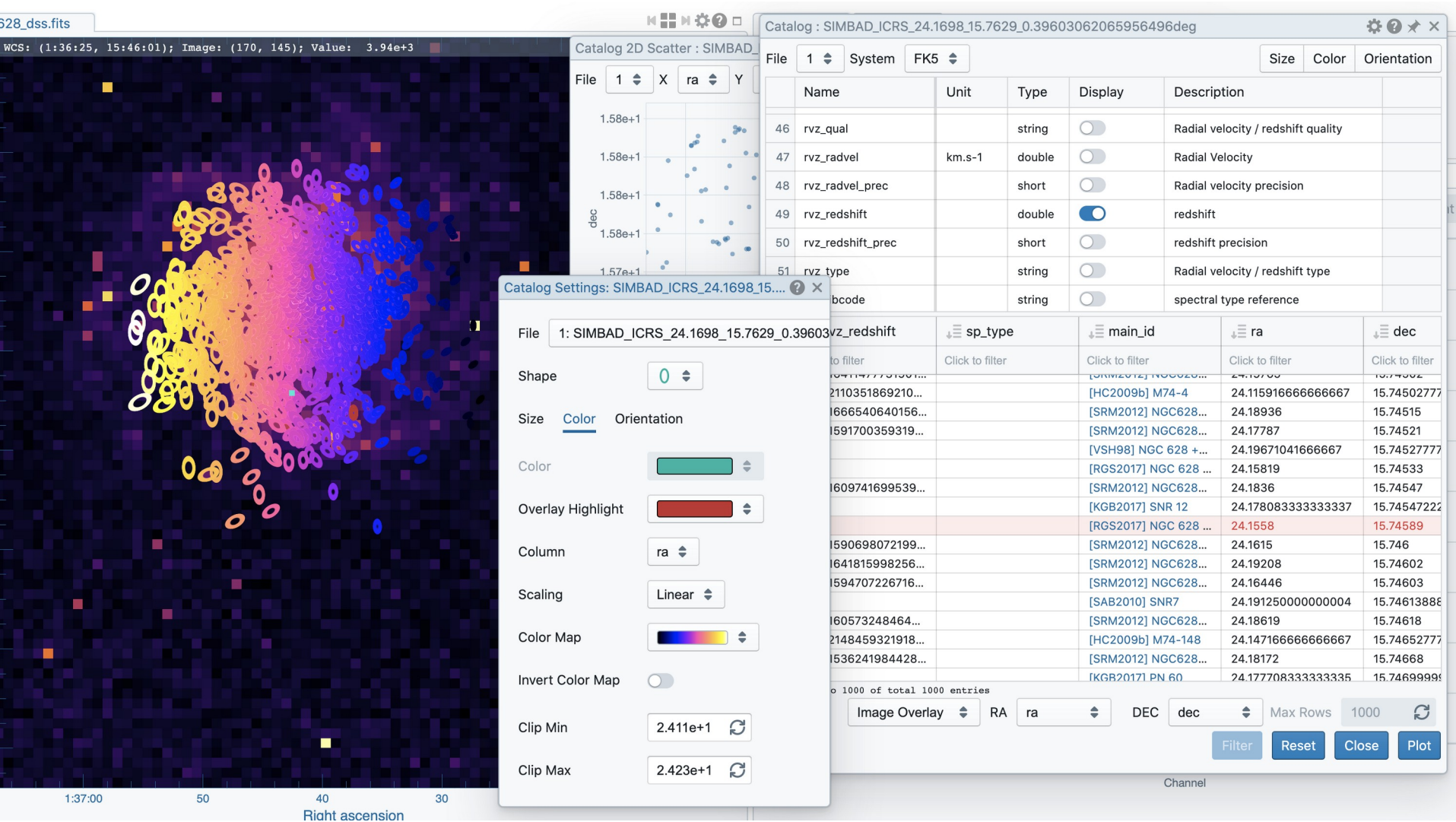
Showing 1 to 1000 of total 1000 entries

Histogram X ra Y dec Max Rows 1000

Filter Reset Close Plot

Channel

# CARTA - Catalog tool





# CARTA - Catalog tool

The screenshot displays the CARTA software interface with the following components:

- Main View:** A star field plot with WCS coordinates (1:36:43, 15:40:36) and a value of 3.714e+3. The plot shows a dense cluster of stars with a color gradient from blue to red. A yellow arrow points to a specific star, and a red arrow points to the bottom toolbar.
- Catalog Panel:** A table titled "Catalog : SIMBAD\_ICRS\_24.1740\_15.7835\_0.7413236287209521deg". It lists various parameters such as Name, Unit, Type, Display, and Description. The table is currently showing 1 to 1000 of 1000 entries.
- Catalog Histogram:** A histogram showing the distribution of Right Ascension (ra) values. The x-axis is labeled "ra" and ranges from 2.42e+1 to 2.42e+1. The y-axis is labeled "Count" and ranges from 0 to 8000. A red vertical line is drawn at approximately 2.42e+1.
- Catalog 2D Scatter:** A scatter plot showing the relationship between Right Ascension (ra) and Declination (dec). The x-axis is labeled "ra" and ranges from 0.00e+0 to 2.50e-3. The y-axis is labeled "dec" and ranges from 1.57e+1 to 1.58e+1. A blue arrow points to a specific data point.

# CARTA - Catalog tool

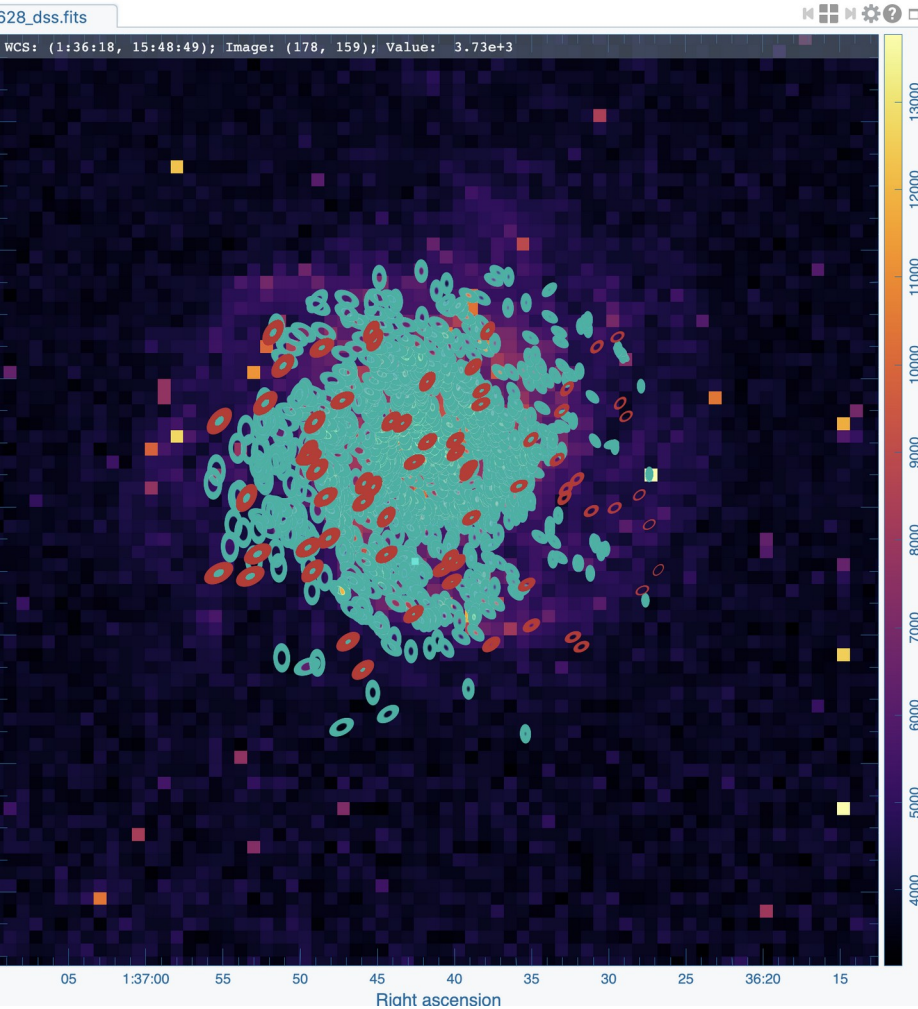


Image List | Animator | Catalog: SIMBAD\_ICRS\_24.1698\_15.7629\_0.5150007572809944deg

File 1 System FK5 Size Color Orientation

Name	Unit	Type	Display	Description
1		string	<input type="checkbox"/>	Coordinate reference
2	deg	short	<input type="checkbox"/>	Coordinate error angle
3	mas	float	<input type="checkbox"/>	Coordinate error major axis

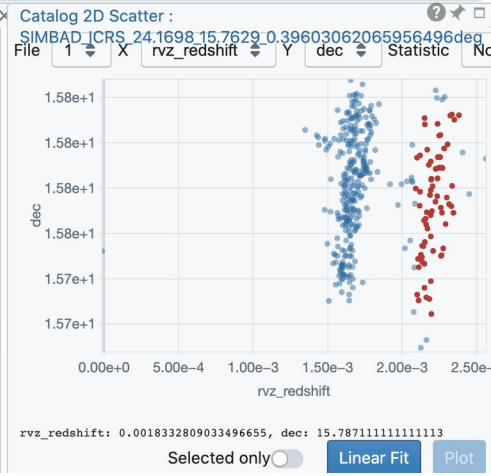
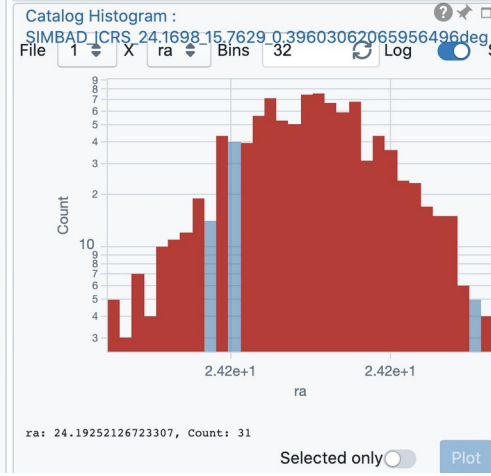
  

rvz_redshift	sp_type	main_id	ra	dec
Click to filter	Click to filter	Click to filter	Click to filter	Click to filter
0.002194925641232...		[HC2009b] M74-19	24.191416666666666	15.724388888888889
0.00207692547720...		[HC2009b] M74-94	24.206458333333333	15.72525
		[SAB2010] SNR5	24.203750000000003	15.726222222222223
		[CHP2004] J013651...	24.213333333333334	15.727500000000004
		[HC2009b] M74-124	24.178416666666667	15.729222222222222
		IYZ1 2016l 257	24.17337	15.73002

Showing 1 to 1000 of total 1000 entries

2D Scatter X rvz\_redsl Y dec Max Rows 1000

Filter Reset Close Plot



# Python scripting in progress

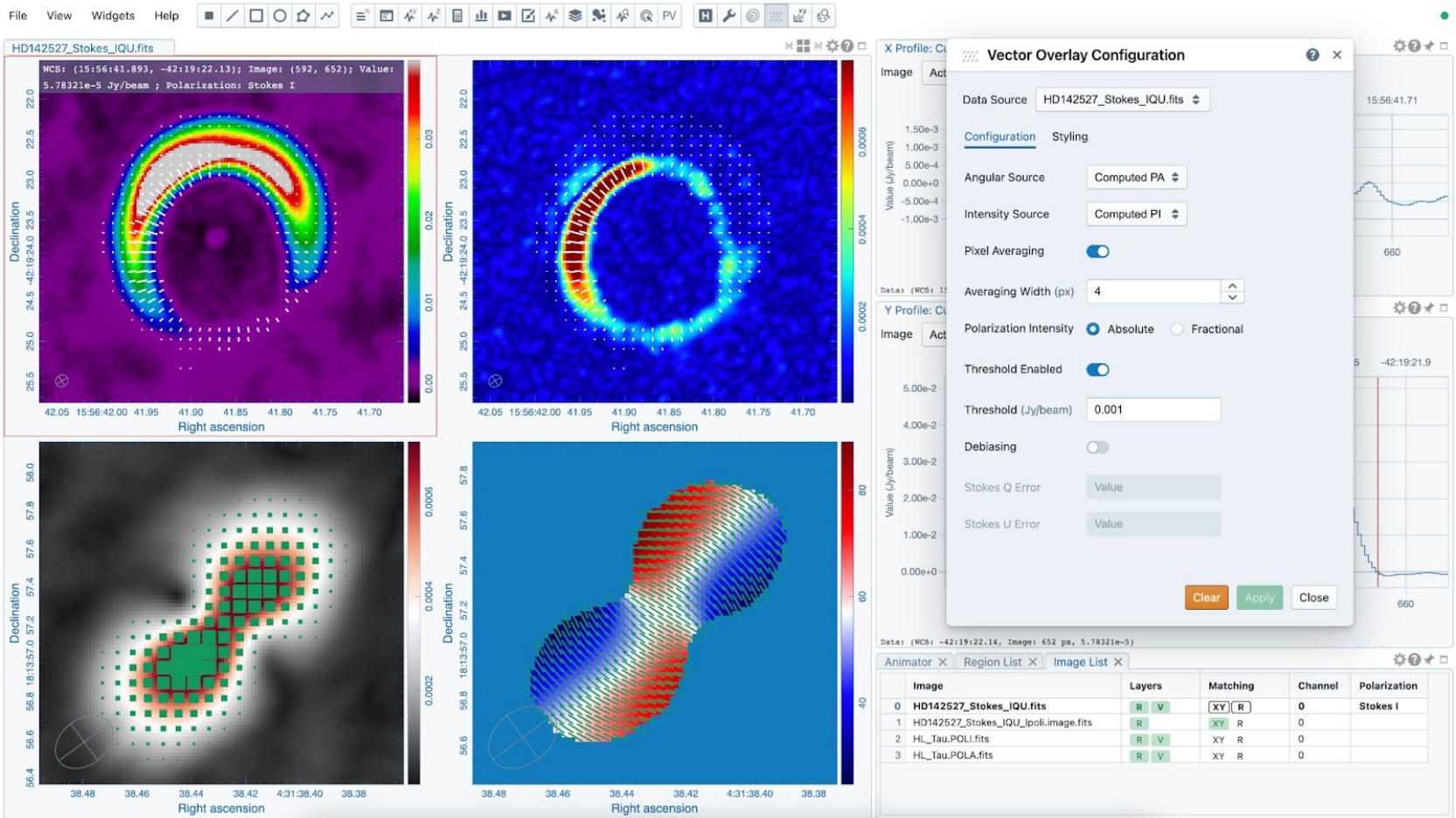
The screenshot displays the CARTA v3 software interface. At the top, a navigation menu shows 'Examples' and 'Tutorial' tabs. The 'Tutorial' tab is active, displaying a list of sections: '01. Basics', '02. Functions', and '03. Loading images'. A 'Create new snippet' button is visible below the 'Examples' tab.

In the foreground, an 'Edit code snippet' window is open, showing Python code for loading images. The code includes comments and function calls like `carta.showSplashScreen()`, `await carta.delay(1000)`, and `app.hideSplashScreen()`. Below the code editor are buttons for 'Execute', 'New', 'Delete', 'Save', and 'Close'.

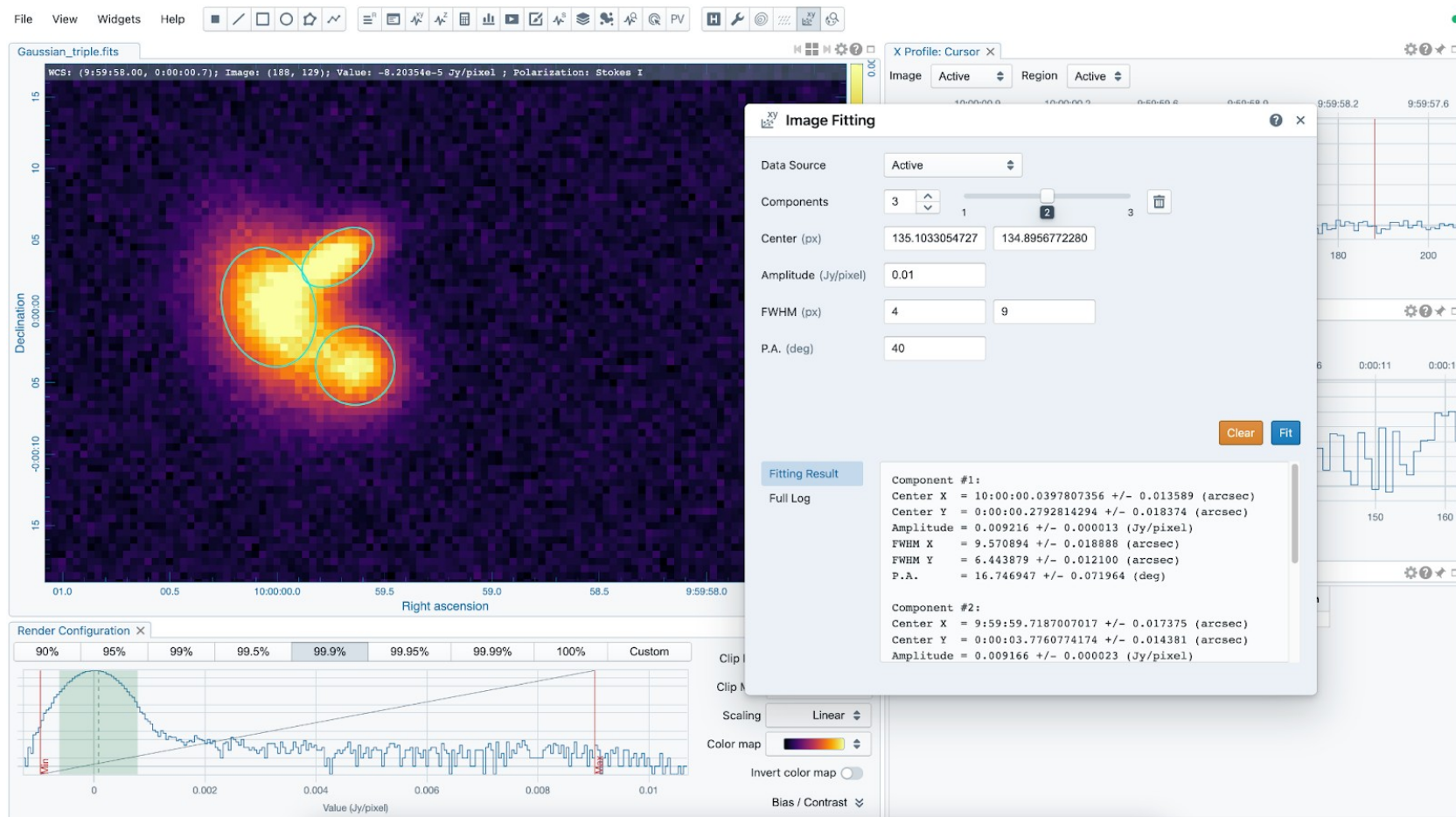
To the right, a 'Preferences' dialog box is open, showing settings for 'Global', 'Render Configuration', 'Contour Configuration', 'Overlay Configuration', 'Catalog', 'Region', 'Performance', 'Telemetry', and 'Log Events'. The 'Global' section is selected, showing options for 'Theme' (Light), 'Enable Code Snippets' (checked), 'Auto-launch File Browser' (checked), 'File List' (Filter by file content), 'Initial Layout' (Default), 'Initial Cursor Position' (Tracking), and 'Initial Zoom Level' (Zoom to fit). There are also 'Restore defaults' and 'Close' buttons.

Below the preferences dialog, two panels are visible, each displaying a folder icon and the text 'No catalog file loaded' with the instruction 'Load a catalog file using the menu'.

# Vector field rendering



# 2D Gaussian Fitting



# LEL image loading (mathematical expressions)

The screenshot displays the CARTA v3 software interface. The main window shows a multi-panel view of astronomical data. The top-left panel displays a 2D image with five bright sources, with axes labeled 'Declination' and 'Right ascension'. The top-right panel shows an 'X Profile: Cursor' plot with 'Value (Jy/beam)' on the y-axis and time on the x-axis. The bottom-left panel shows a 'Render Configuration' window with a histogram and a 'Color map' dropdown. A 'File Browser' window is open in the center, showing a list of FITS files and their metadata.

**File Browser**

Filename	Type	Size	Date
dice_five.fits	FITS	86.4 kB	27 Feb 2021
dice_four.fits	FITS	86.4 kB	27 Feb 2021
dice_one.fits	FITS	86.4 kB	27 Feb 2021
dice_six.fits	FITS	86.4 kB	27 Feb 2021
dice_three.fits	FITS	86.4 kB	27 Feb 2021
dice_two.fits	FITS	86.4 kB	27 Feb 2021

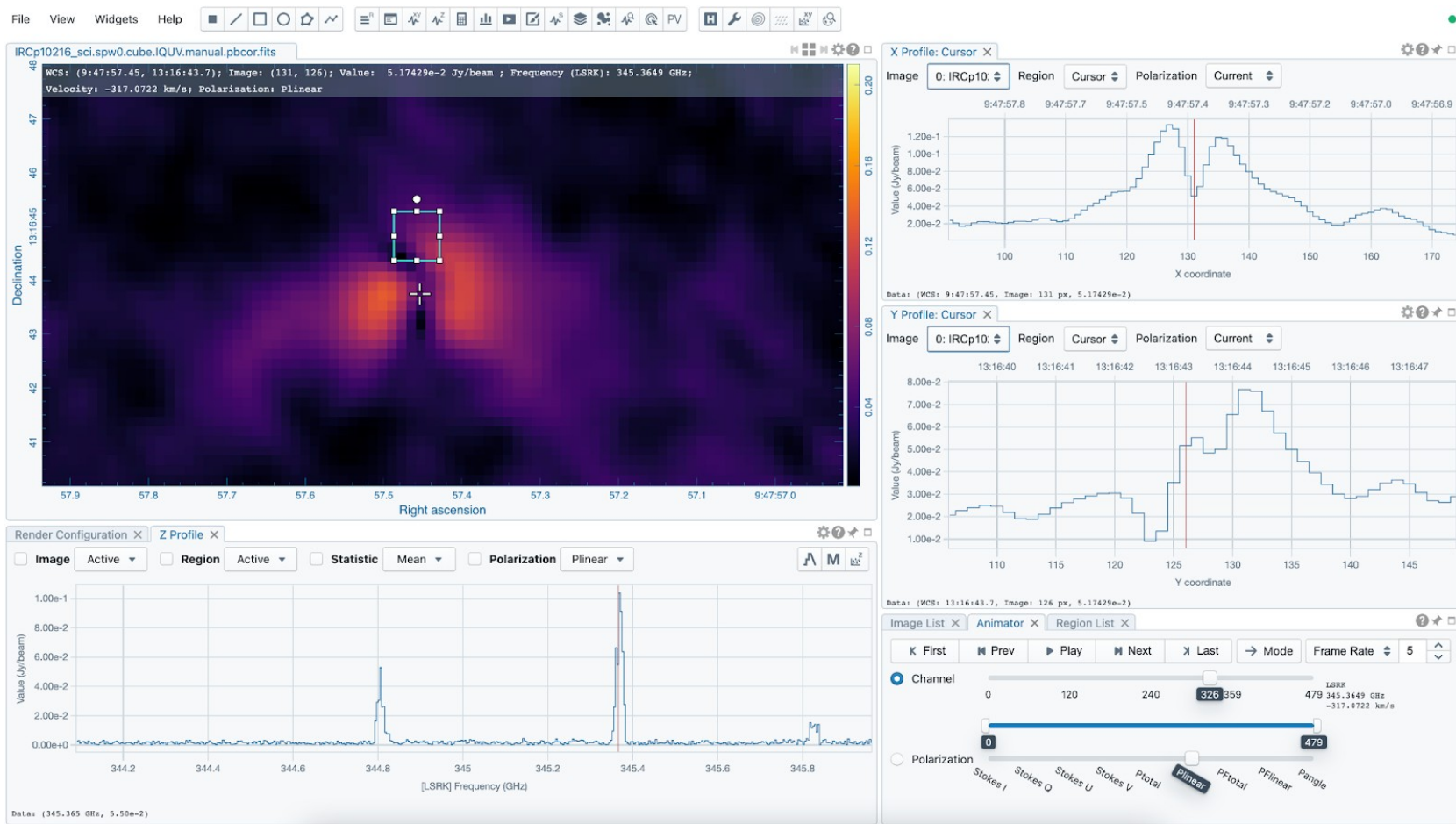
**File Information**

```
Name = dice_one.fits
HDU = 0
Data type = double
Shape = [101, 101]
Coordinate type = Right Ascension, Declination
Projection = SIN
Image reference pixels = [320.75, 320.75]
Image reference coords = [06:12:53.8000, +017:59:22.1000]
Image ref coords (deg) = [93.2242 deg, 17.9895 deg]
Pixel increment = -0.03", 0.03"
Pixel unit = Jy/beam
Celestial frame = ICRS
Restoring beam = 0.150481" X 0.108465", 11.5153 deg
RA range = [06:12:54.262, 06:12:54.472]
DEC range = [+17:59:12.507, +17:59:15.507]
```

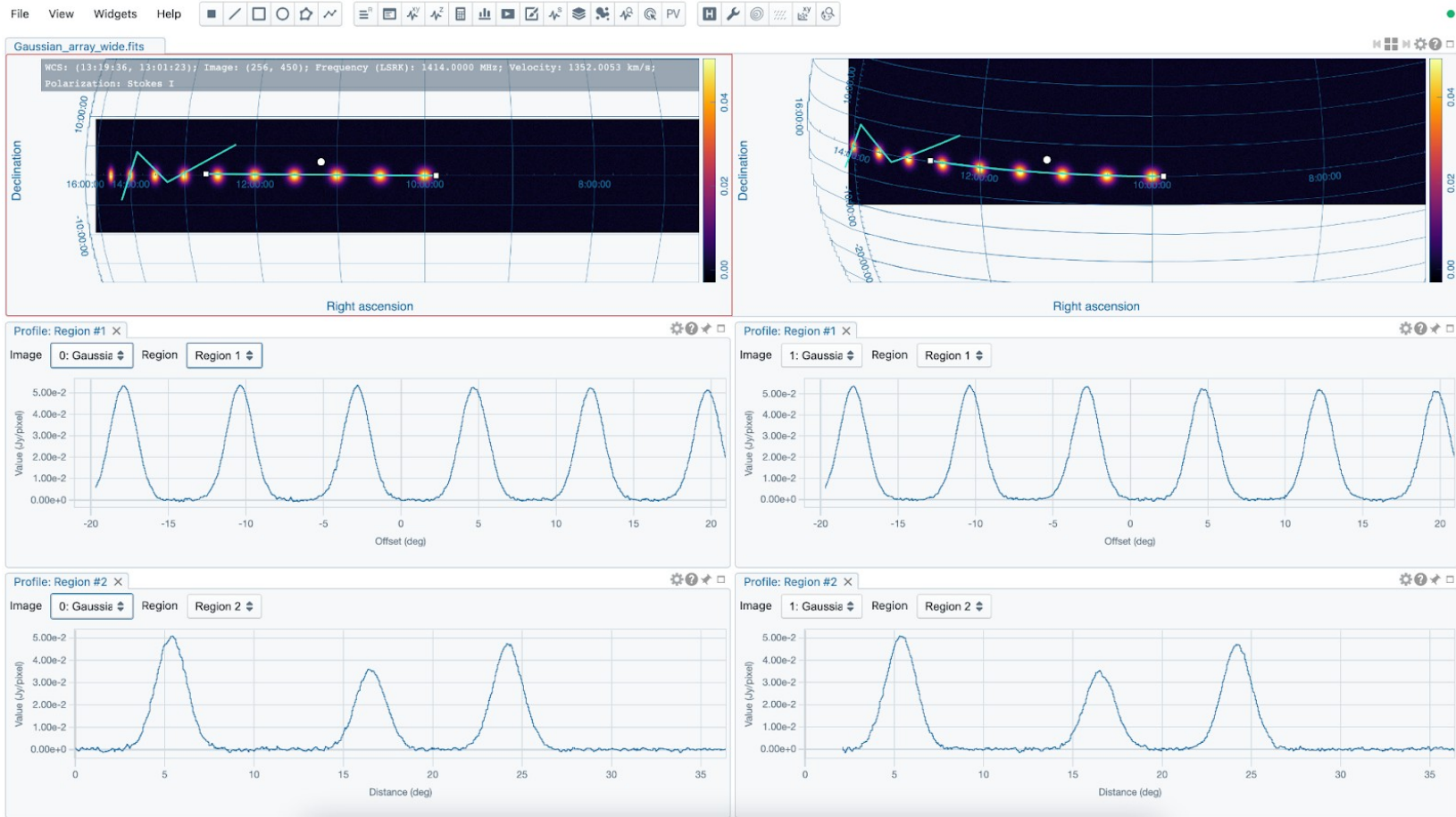
**Image arithmetic** "dice\_four.fits" + "dice\_one.fits"

Close Load expression

# Generation of polarization products (Pint, PA)




# Line and Polyline spatial profiles






# SRDP image archive

version: 4.1.0



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

View Projects    View Observations    View Images

«   <   Page 1   >   »

Show 25 of 52948 Images

0/50: selected (0/10.0 TB)

View Selection(s)    Clear All    Download    View In Carta

	↕ Project	↕ Longitude	↕ Latitude	↕ Band	Sp Resolution	Beam Axis Ratio	↕ File Name
 	VLASS1.1	0h2m28.328s	-36°30'0.000"	S	2.520	2.554	VLASS1.1.ql.T01t01.J000228-363000.10.2048.v1.l.iter1.image.pbcor.tt0.subim.fits
 	VLASS1.1	0h2m30.256s	-37°30'0.000"	S	2.460	1.975	VLASS1.1.ql.T01t01.J000230-373000.10.2048.v1.l.iter1.image.pbcor.tt0.subim.fits
 	VLASS1.1	0h2m32.282s	-38°30'0.000"	S	2.486	1.534	VLASS1.1.ql.T01t01.J000232-383000.10.2048.v1.l.iter1.image.pbcor.tt0.subim.fits
 	VLASS1.1	0h2m34.411s	-39°30'0.000"	S	2.621	1.270	VLASS1.1.ql.T01t01.J000234-393000.10.2048.v1.l.iter1.image.pbcor.tt0.subim.fits
 	VLASS1.1	0h7m24.984s	-36°30'0.000"	S	2.518	2.440	VLASS1.1.ql.T01t01.J000724-363000.10.2048.v1.l.iter1.image.pbcor.tt0.subim.fits
 	VLASS1.1	0h7m30.769s	-37°30'0.000"	S	2.455	1.881	VLASS1.1.ql.T01t01.J000730-373000.10.2048.v1.l.iter1.image.pbcor.tt0.subim.fits
 	VLASS1.1	0h7m36.847s	-38°30'0.000"	S	2.502	1.462	VLASS1.1.ql.T01t01.J000736-383000.10.2048.v1.l.iter1.image.pbcor.tt0.subim.fits
 	VLASS1.1	0h7m43.233s	-39°30'0.000"	S	2.645	1.224	VLASS1.1.ql.T01t01.J000743-393000.10.2048.v1.l.iter1.image.pbcor.tt0.subim.fits

# SRDP image archive

version: 4.1.0

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1/50: selected (55.4 MB)

View Selection(s) Clear All Download View In Carta

View Projects View Observations View Images

Show 25 of 52948 Images

### Launch Workflow Task on: VLASS1.1

**User Email (required):**

**Request Description:**

**Destination Directory:**  Specify directory (must be logged in & staff)

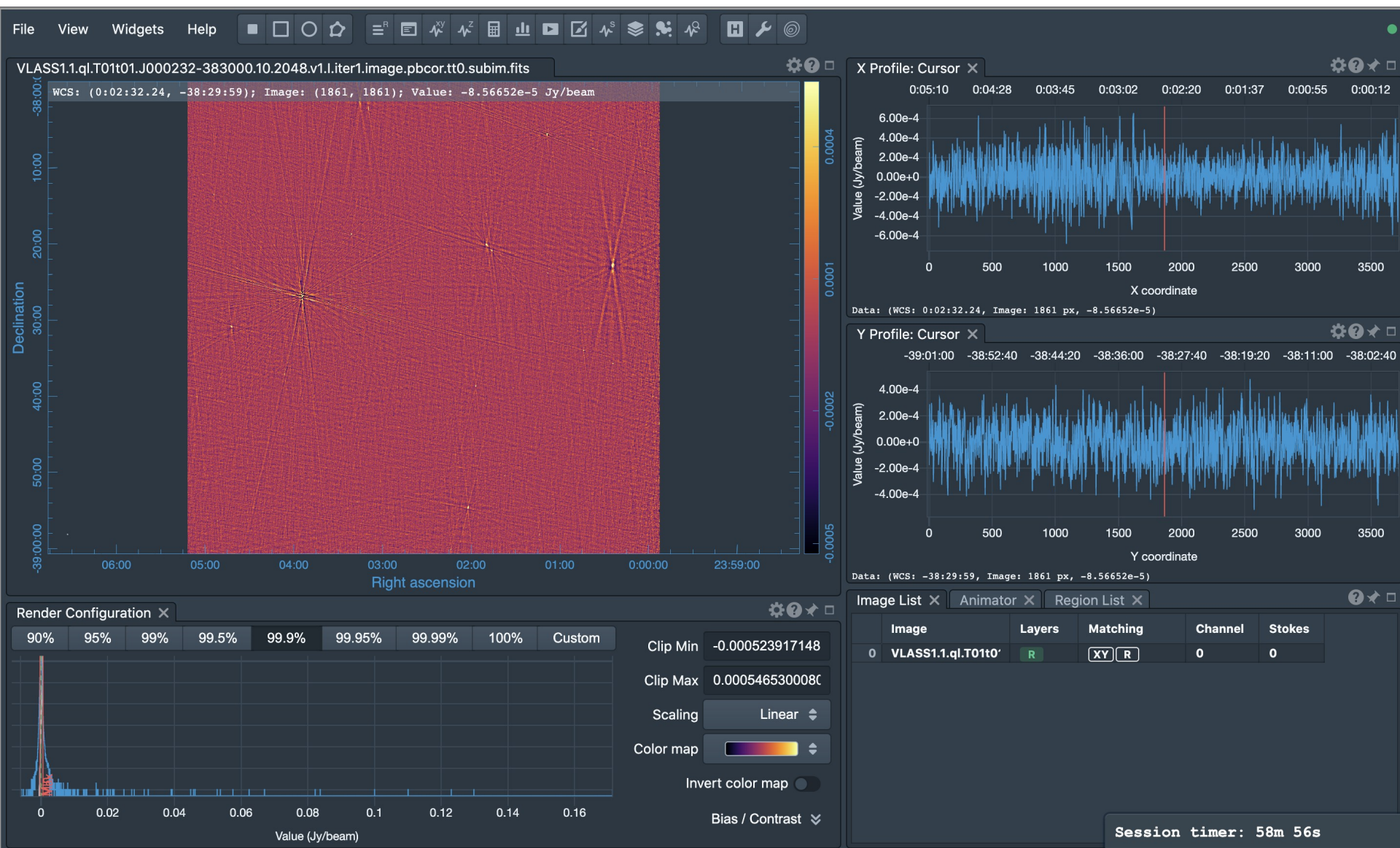
**Create tar file:**  Return results as a tar file

**Visualize with CARTA:**  Visualize Images with CARTA

Cancel Submit Request

Project	Longitude	Latitude	Band	Sp Resolution	Beam Axis Ratio	File Name
VLASS1.1	0h2m28.328s	-36°30'0.000"	S	2.520	2.554	VLASS1.1.q1.T01t01.J000228-363000.10.2048.v1.l.iter1.image.pbcor.tt0.subim.fits
VLASS1.1	0h2m30.256s	-37°30'0.000"	S	2.460	1.975	VLASS1.1.q1.T01t01.J000230-373000.10.2048.v1.l.iter1.image.pbcor.tt0.subim.fits
VLASS1.1	0h2m32.282s	-38°30'0.000"	S	2.486	1.534	VLASS1.1.q1.T01t01.J000232-383000.10.2048.v1.l.iter1.image.pbcor.tt0.subim.fits
VLASS1.1	0h2m34.411s	-39°30'0.000"	S	2.621	1.270	VLASS1.1.q1.T01t01.J000234-393000.10.2048.v1.l.iter1.image.pbcor.tt0.subim.fits
VLASS1.1	0h7m24.984s	-36°30'0.000"	S	2.518	2.440	VLASS1.1.q1.T01t01.J000724-363000.10.2048.v1.l.iter1.image.pbcor.tt0.subim.fits
VLASS1.1	0h7m30.769s	-37°30'0.000"	S	2.455	1.881	VLASS1.1.q1.T01t01.J000730-373000.10.2048.v1.l.iter1.image.pbcor.tt0.subim.fits
VLASS1.1	0h7m36.847s	-38°30'0.000"	S	2.502	1.462	VLASS1.1.q1.T01t01.J000736-383000.10.2048.v1.l.iter1.image.pbcor.tt0.subim.fits
VLASS1.1	0h7m43.233s	-39°30'0.000"	S	2.645	1.224	VLASS1.1.q1.T01t01.J000743-393000.10.2048.v1.l.iter1.image.pbcor.tt0.subim.fits

# SRDP archive



# CARTA

**Development for v4 (release in 2023, but beta versions with subset of features will be available sooner):**

- Save, restore state
- Share states
- Interactive position-velocity plots
- 2D image fitting
- RGB image blender
- Spatial profile fitting
- Histogram improvements with custom parameters
- Image annotation
- Channel maps
- Scripting interface

Later:

- Volume (3D) rendering
- Improved Profile, histogram, and image fitting tools
- Source finder
- Transposed cubes
- Image smoothing
- VR integration (IDaVie)

# CARTA

- CARTA is the new visualization tool, actively developed for radio image formats (but can be used for any fits image [cube]). It replaces the CASAviewer that is not supported anymore.
- Performance and architecture of CARTA are ideal for displaying large images hosted locally (VLA, ALMA, ...) or remotely (SKA, ngVLA, VLASS, ...)
- Almost all CASAviewer functionality is now available in CARTA v3, it is now a good time to switch over
- CARTA is integrated in the ALMA and NRAO/SRDP archives
- Python scripting is under active development
- For questions, comments, suggestions, please contact the CARTA helpdesk [support@carta.freshdesk.com](mailto:support@carta.freshdesk.com)
- CARTA homepage: [cartavis.org](http://cartavis.org)



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